Thesis Proposal

How to design a sustainable energy infrastructure for future cities?

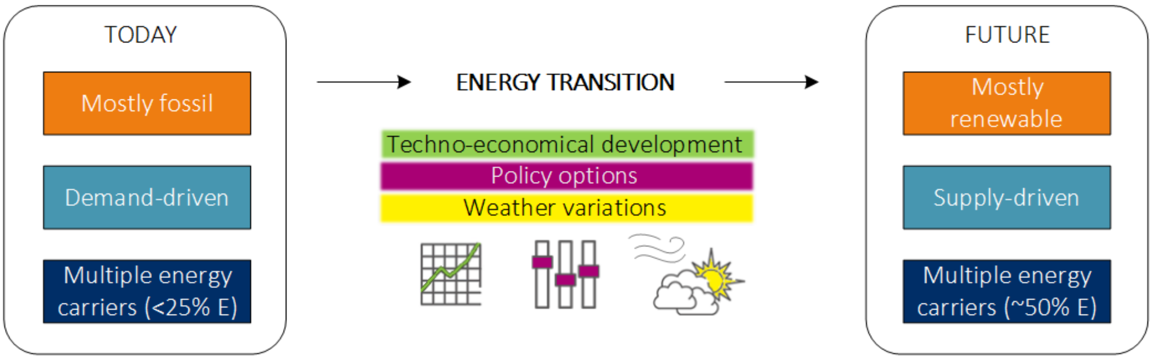
Problem background

In order to stay within a maximum of 2 degrees global warming, the global carbon emissions need to decrease significantly. Estimations show the world needs to reduce 80%-95% of its carbon emissions by 2050[1]. Most of these emissions originate in cities (>70%)[2], and simultaneously, cities are most affected by climate change consequences. For example, over 90% of all urban areas are coastal, putting them at risk of flooding from rising sea levels and powerful storms[3]. Hence, they are often most motivated to act; to really accelerate the energy transition towards a sustainable future. Even leading the way when national governments lag. Yet though these cities often have certain sustainability goals for 2050, they don't know how to get there.

Challenges

Such an immense reduction of carbon emissions entails an almost complete shift from the fossil-based sources of today, to the renewable energy sources (RES) of tomorrow, which leads to two major challenges:

- Most RES generate electricity, yet currently just 20% of the final energy demand is electric[4]. This calls for more demand electrification or conversion of electricity to other energy *carriers*.
- The most important RES, wind and solar, both generate electricity in what is called an intermittent or variable manner. Only when the wind blows, or the sun shines. Of course, this varies between day and night, but also between seasons, and even interannually[5].



Existing energy infrastructure, assets both on supply and demand side

New or developing assets, forecasted demand scenarios & climate goals

The figure above[6] depicts these and other energy transition challenges. The transition to a mostly renewable energy supply also means a transition of a demand-driven to a supply-driven system, and generally to a more decentralized system. During the energy transition, besides weather variations, both techno-economic developments and policy options are also relevant drivers to consider.

[1] European Commission, Going climate neutral by 2050, https://tinyurl.com/yagxd67c (2019)
[2] United Nations Environment Programme, Global Initiative for Resource Efficiency in Cities, www.unep.org/pdf/GI-REC_4pager.pdf (2012)
[3] 40, AXA, Understanding infrastructure interdependencies in cities,Tech. rep., C40 Cities and Axa S.A. (2019)
[4] International Energy Agency, Sankey Diagram – World Balance 2017, www.iea.org/sankey (2017)
[5] Wiser, et al., Wind Energy (in IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, (2011)
[6] Van Beuzekom, et al., Framework for optimization of long-term, multi-stage investment planning of integrated energy systems. (2021)

Approach

How can a city's energy infrastructure be designed such that a large-scale implementation of RES and significant reduction of CO_2 emissions can be achieved? A promising approach calls for a stronger integration of different energy infrastructures[7][8]. Some energy carriers can be converted from one to another, creating opportunities to use the different characteristics of each carrier. For instance, different energy carriers are stored more efficiently at different time scales. This creates more degrees of freedom, yet it also adds complexity, because it integrates different network layers, and different time scales[9].

We designed an optimization framework to integrate these multiple energy systems, implemented it in a Python model and tested it for long-term design from today to 2050. However, both computational, as well as practical challenges remain. Do you want to help upgrade our optimization model? From small to large scale cases, integrating operational constraints, or using existing asset data to create a *brownfield* design (instead of *greenfield)*. Or, if you have your own data, you can make a design for your (city) case study!

Requirements

- A master student in a relevant engineering, mathematical or computer science field,
- Passionate about (future) energy technologies and energy transition developments,
- A team player with great work ethic,
- A puzzle solver with excellent analytical skills, modeling and programming experience,
- Depending on the thesis subject – experience with decomposition methods, data science, or (chemical/electrical/materials) engineering can be an advantage
- Able to fluently communicate in English (verbally and in writing).

What we offer

- Entrance to the most passionate powerhouse in applied mathematics, with a drive to use our skills to improve the world, from the world at large to our own backyard;
- Being part of a company founded by graduate students back in 1981, which today still fosters its students by
    - Excellent supervision during your graduation project
    - Possibility to work as a Student Assistant next to your graduation project
    - Good internship allowance and a laptop
- An open, kind and fun culture, with both an active employee association for fun activities with colleagues and content driven Young ORTEC organization for you to join;
- Being a member of the Student Pool, which organizes all kinds of activities for graduate students at ORTEC, like Friday afternoon drinks at our own "ORTap";
- Being part of the Energy team, where we often organize both fun and educational activities. Think of cake at our team meetings, pizza sessions with a deep dive into a part of our industry, coffee meetings where we discuss latest developments in the industry, and a yearly team weekend.

Practical details

- Start date: asap (possibly in conjunction with other graduates)
- Location: Zoetermeer, ORTEC HQ & Online via Microsoft Teams (on an ORTEC laptop)
- ORTEC supervisor: Iris van Beuzekom, also PhD researcher
- Apply today via recruitment@ortec.com (include your resume, motivation and grade list)

At ORTEC we leverage data & mathematics to create value for businesses and society at large. Visit our website www.ortec.com to learn more about ORTEC and what our 1000 employees from around the world are up to!

[7] M. Geidl, et al., The energy hub, a powerful concept for future energy systems, in: 3rd Annual Carnegie Mellon Conf. on the Electricity Industry, Pittsburgh,PA, USA, (2007), pp. 1–6.
[8] M. Ruth, B. Kroposki, Energy systems integration: an evolving energy paradigm, The Electricity Journal 27 (6) (2014) 36–47
[9] P. Mancarella, MES (multi-energy systems): An overview of concepts and evaluation models, Energy 65 (2014) 10–17